Proposal Title: Centrifugally Powered Pneumatic De-Icing for Helicopter Rotor Blades

Principal Investigator: Jose Palacios (Pennsylvania State University)

Co-Investigators/Team Members: Doug Daley (Self), Joseph Szefi (Invercon, LLC)

Abstract:

The innovative aspect of centrifugally powered pneumatic de-icing relies on the semi-passive nature of the concept. Air pressure generated due to centrifugal forces, acts on air contained in volumes running span-wise inside the rotor blades. The pressure generated is used to deploy pneumatic diaphragms located in the leading edge of the blade where ice accretes. These diaphragms deform an erosion resistant metallic leading edge cap, promoting ice delamination. The deformation introduces ice interface transverse shear stresses that exceed the adhesion strength of the ice to the surface. The ice debonding is instantaneous (within 300 ms from the beginning of the actuation), and azimuthal ice shedding could be controlled, avoiding ice impact ballistic concerns related to shedding over the tail or the front of the vehicle. The proposed extremely low-power method is non-thermal, allowing its application to with other erosion resistant coatings that might not have the thermal conductivity needed to function with electrothermal de-icing. Also, the low-power consumption of the system allows its implementation to vehicles that currently cannot afford the installation of electrothermal rotor blade ice protection. Proof-of-concept rotor ice testing on a span-truncated rotor (5 ft. radius) was successfully conducted during a NASA LEARN Phase I effort. The system protected from ice formation exceeding 0.2 in. for extreme icing conditions as described in the icing envelope and was able to shed ice accretion as low as 0.06 in at temperatures above -15 deg. C. During Phase II, full-scale rotor testing is proposed, such that the system is powered by centrifugal loads inherent to the rotor system and without a pneumatic slip-ring. Icing conditions will be reproduced with portable ice cloud generators that will be designed and fabricated during the proposed research effort.

The research effort will be conducted by the Pennsylvania State University, Invercon LLC., and Kaman. Bell Helicopter will provide engineering services and guidelines to minimize system integration issues related to current rotor manufacturing and operation constraints.